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Dexmedetomidine versus Dexamethasone as an Adjuvant to Bupivacaine in Ultrasound-Guided Transversus Abdominis Plane Block for Total Laparoscopic Hysterectomy: A Comparative Observational Study of Postoperative Analgesia.

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Abstract

Background: Ultrasound-guided transversus abdominis plane block (TAP block) is an effective component of multimodal analgesia for total laparoscopic hysterectomy (TLH). However, the local anesthetics alone analgesic effect has a limit. This research study in an Indian tertiary healthcare settings aimed to compare the clinical efficacy of dexmedetomidine versus dexamethasone as perineural adjuvants to bupivacaine in TAP block for post-operative analgesia following TLH. ***Methods:*** The study was an observational study that was comparative, prospective and was done over a period of 6 months. Ninety adult women (ASA physical status I–II; age range, 35–65 years) undergoing an elective TLH (Total laparoscopic hysterectomy) under standardised general anaesthesia were included. On clinical allocation and before the end of the surgery, all the patients received bilateral ultrasound-guided TAP block under GA with either bupivacaine plus dexmedetomidine (Group DEX-M, n = 45; 20 mL 0.25% bupivacaine + 0.5 mcg/kg dexmedetomidine per side) or bupivacaine plus dexamethasone (Group DEX-A, n = 45; 20 mL 0.25% bupivacaine + 4 mg dexamethasone per side). The main goal was how long the pain killer would last before the doctor was called. The total tramadol consumed post operation over 24 hours, Visual Analogue Score (VAS) for pain, score of sedation, and incidence of postoperative nausea vomiting (PONV) were secondary endpoints. ***Results:*** The surgical and demographic characteristics at baseline were similar between the groups. The average time that pain relief lasted (hours) was significantly higher in group DEX-M than DEX-A (14.8 ± 2.6 vs 11.4 ± 2.2, $p < 0.001$). In parallel, the total of 24 hours postoperative tramadol consumption was significantly lower in Group DEX-M (68.4 ± 18.5 mg vs. 92.6 ± 24.2 mg, $p<0.001$). At the 12th and 18th hour postoperatively, VAS pain scores at rest and during movement were significantly lesser in Group DEX-M ($p < 0.01$). The PONV in group DEX-A was less in comparison to group DEX-M (8.9% vs 24.4%; p=0.04). Moreover, the incidence of mild transient early postoperative sedation was more in group DEX-M as compared to group DEX-A (15.6% vs 2.2%; p=0.03) ***Conclusion:*** Both adjuvants significantly enhance the efficacy of TAP block in TLH. Through reduced opioid consumption, Dexmedetomidine provides better and prolonged postoperative analgesia whereas dexamethasone offers its own antiemetic advantages with lower sedation in the early moments.

Keywords: Transversus Abdominis Plane Block; Dexmedetomidine; Dexamethasone; Total Laparoscopic Hysterectomy; Postoperative Analgesia.

INTRODUCTION

Total laparoscopic hysterectomy (TLH) is an increasingly popular surgical option for benign and early malignant pathologies in the uterus. Compared to abdominal hysterectomy, TLH has benefits of significantly less intraoperative blood loss, which results in shorter hospital stay and faster return to functional baseline [1, 2]. Even though TLH is a minimally invasive surgery, it still results in moderate to severe postoperative pain. This is due to a combination of somatic abdominal wall pain at the port insertion sites, visceral pain as a result of peritoneal manipulation and uterine dissection, and diaphragmatic irritation caused by carbon dioxide pneumoperitoneum [2, 3]. Poorly managed acute postoperative pain causes distress to the patient, prevents early ambulation, increases the likelihood of postoperative pulmonary and thromboembolic complications, and prolongs the length of stay as an inpatient [1, 4].

Opioid-based intravenous analgesia (IV) has traditionally been the postoperative analgesia standard of care. However, systemic opioids are commonly associated with dose-limiting adverse effects and side effects, such as (post-operative nausea and vomiting) PONV, sedation, ileus and respiratory depression [3, 5]. Enhanced Recovery After Surgery (ERAS) protocols strongly recommend opioid-sparing multimodal analgesic regimens [4, 5] to mitigate these negative effects. One of the regional anesthesia techniques, ultrasound-guided transversus abdominis plane (TAP) block has emerged as a safe, reproducible, and highly effective regional analgesic technique which blocks anterior abdominal wall afferent neural signals (T6–L1) thereby significantly reducing parietal somatic pain following laparoscopic pelvic surgery [3, 6].

The main drawback of a single-shot TAP block with either bupivacaine or ropivacaine is the limited duration of the block, which is typically 6 to 8 hours and will require supplementary systemic analgesia during the crucial night post-surgery [5, 7]. Several perineural adjuvants have been studied to prolong the duration of sensory blockade [6, 8]. Two substances, dexmedetomidine (a highly selective alpha-2 adrenergic agonist) and dexamethasone (a powerful synthetic corticosteroid, which is a variant of the natural hormone produced by the body) have found to be significantly effective in prolonging the duration of peripheral nerve block via different mechanisms of action [7, 8].

Veterinary studies have tested these adjuvants across a heterogenous application to a broad range of abdominal and orthopedic procedures [6, 8]. However, there exists little comparative clinical evidence on the relative superiority of perineural dexmedetomidine over dexamethasone in bilateral ultrasound-guided TAP block for TLH in an Indian tertiary healthcare setting. The aim of the prospective observational study was to compare the duration of analgesia, 24 hour opioid consumption and side effect profile of dexmedetomidine versus dexamethasone as an adjuvant to bupivacaine in ultrasound guided TAP block for patients undergoing elective total laparoscopic hysterectomy at a tertiary care hospital in Bengaluru.

MATERIALS AND METHODS

Study Design and Setting

This prospective, comparative, observational clinical study was conducted over a continuous 6-month period in the Department of Anaesthesiology and Obstetrics & Gynaecology at a Level-I tertiary care medical hospital in Bengaluru, Karnataka. The study protocol was formally reviewed and approved by the Institutional Ethics Committee prior to study initiation. Written informed consent was obtained from all participating patients in accordance with the ethical principles of the Declaration of Helsinki.

Patient Selection and Eligibility Criteria

A total of N = 90 adult women undergoing elective total laparoscopic hysterectomy under general anaesthesia during the 6-month study window were enrolled sequentially.

Inclusion Criteria: Women aged 35 to 65 years, American Society of Anesthesiologists (ASA) physical status I or II, body mass index (BMI) between 18.5 and 30.0 kg/m², scheduled for elective TLH for benign uterine pathologies (e.g., symptomatic leiomyoma, adenomyosis, dysfunctional uterine bleeding).

Exclusion Criteria: Patient refusal, ASA physical status III or higher, known allergy or hypersensitivity to amide local anesthetics, dexmedetomidine, or corticosteroids, coagulation bleeding disorders or anticoagulant therapy, localized infection at the abdominal abdominal wall injection site, pre-existing chronic pain syndromes or opioid dependency, and conversion of laparoscopic surgery to open laparotomy.

Group Allocation and TAP Block Protocol

Based on the clinical analgesic regimen prescribed by the attending anesthesiologist, patients were stratified into two comparative cohorts of 45 patients each:
Group DEX-M (n = 45): Received bilateral ultrasound-guided TAP block using 20 mL of 0.25% bupivacaine combined with dexmedetomidine at a dose of 0.5 mcg/kg per side (total volume 20 mL per side, diluted with normal saline).
Group DEX-A (n = 45): Received bilateral ultrasound-guided TAP block using 20 mL of 0.25% bupivacaine combined with dexamethasone at a dose of 4 mg (1 mL) per side (total volume 20 mL per side).

All patients underwent standardized general anaesthesia induction using intravenous propofol (2 mg/kg) and fentanyl (2 mcg/kg), facilitated by vecuronium (0.1 mg/kg) for endotracheal intubation. Anaesthesia was maintained with sevoflurane in an oxygen-air mixture targeting a MAC of 0.9–1.1. Intraoperative mechanical ventilation was adjusted to maintain end-tidal CO2 between 35 and 40 mmHg.

At the conclusion of surgery, prior to extubation, bilateral TAP blocks were performed under strict aseptic precautions using a high-frequency linear ultrasound transducer (8–13 MHz). The transducer was placed transversely between the iliac

crest and the subcostal margin in the mid-axillary line. Once the three muscular layers of the abdominal wall (external oblique, internal oblique, and transversus abdominis) were clearly visualized, a 22-gauge 50-mm regional anesthesia needle was introduced using an in-plane approach. Upon reaching the neurovascular fascial plane between the internal oblique and transversus abdominis muscles, correct tip placement was confirmed by hydrodissection with 2 mL of saline, followed by injection of the allocated 20 mL study solution on each side. Patients were subsequently extubated and transferred to the post-anaesthesia care unit (PACU).

Postoperative Analgesia and Outcome Measures

In the postoperative ward, all patients received scheduled multimodal analgesia comprising intravenous paracetamol 1 g every 8 hours. The severity of postoperative pain was evaluated using a 10 -point Visual Analogue Scale (VAS; 0 = no pain, 10 = worst imaginable pain) at rest and during coughing/movement at 2, 4, 6, 12, 18, and 24 hours post-surgery by an independent investigator blinded to the adjuvant group. When a patient reported a VAS score ≥ 4 or explicitly requested pain relief, intravenous tramadol 50 mg was administered as rescue analgesia.

The primary endpoint was the duration of analgesia, defined as the time elapsed from completion of the TAP block to the patient's first request for rescue analgesia (tramadol). Secondary endpoints included cumulative 24-hour tramadol consumption, serial VAS pain scores, sedation levels evaluated using the Ramsay Sedation Scale (RSS; scores ≥ 3 considered clinically significant sedation), and the incidence of postoperative adverse events including PONV, bradycardia (heart rate < 50 bpm), and hypotension (mean arterial pressure < 65 mmHg).

Statistical Analysis

Compiled data were verified and analyzed using standard statistical software. Continuous variables were assessed for normal distribution using the Shapiro-Wilk test. Normally distributed continuous data were presented as mean ± standard deviation (SD) and compared between groups using Student's independent two-tailed t-test. Non-parametric continuous data were compared using the Mann-Whitney U test. Categorical variables were expressed as absolute numbers and percentages (%) and analyzed using Pearson's χ^2 test or Fisher's exact test as appropriate. A two-tailed p-value < 0.05 was considered statistically significant.

RESULTS

During the 6-month study window at the tertiary care hospital in Bengaluru, 90 patients completing the standardized TLH and TAP block protocol were analyzed (45 in Group DEX-M and 45 in Group DEX-A). Baseline demographic and surgical characteristics, including maternal age, body mass index (BMI), ASA physical status distribution, operative duration, and estimated blood loss, were well matched between the two cohorts without statistically significant differences (Table 1). The mean age of the total cohort was 46.4 ± 6.8 years, and the mean surgical duration across all laparoscopic hysterectomies was 112 ± 22 minutes.

Table 1: Baseline Demographic and Perioperative Characteristics of Patients Receiving Perineural Dexmedetomidine (DEX-M) or Dexamethasone (DEX-A) during Laparoscopic Hysterectomy with Transversus Abdominis Plane Block

Demographic / Clinical Parameter	Group DEX-M (n = 45)	Group DEX-A (n = 45)	p-value
Age (years), Mean ± SD	46.2 ± 6.5	46.8 ± 7.1	0.68
Body Mass Index (BMI, kg/m²), Mean ± SD	25.4 ± 2.8	24.9 ± 3.1	0.43
ASA Physical Status (I / II), n (%)	28 (62.2%) / 17 (37.8%)	30 (66.7%) / 15 (33.3%)	0.66
Primary Uterine Pathology, n (%)			
Symptomatic Leiomyoma	24 (53.3%)	26 (57.8%)	0.67
Adenomyosis / Endometriosis	13 (28.9%)	11 (24.4%)	0.63
Dysfunctional Uterine Bleeding	8 (17.8%)	8 (17.8%)	1.00
Duration of Surgery (minutes), Mean ± SD	114 ± 24	110 ± 20	0.39
Duration of Anesthesia (minutes), Mean ± SD	132 ± 26	128 ± 22	0.43
Estimated Intraoperative Blood Loss (mL)	145 ± 40	150 ± 45	0.58

Evaluation of primary and secondary analgesic endpoints demonstrated statistically significant differences in block duration and opioid-sparing efficacy between the two perineural adjuvants (Table 2). The mean duration of analgesia (time to first rescue tramadol request) was significantly prolonged in patients receiving dexmedetomidine (Group DEX-M) compared to those receiving dexamethasone (Group DEX-A) (14.8 ± 2.6 hours vs. 11.4 ± 2.2 hours, p < 0.001).

Concurrently, cumulative 24-hour postoperative tramadol consumption was markedly reduced in Group DEX-M, with patients requiring a mean of 68.4 ± 18.5 mg compared to 92.6 ± 24.2 mg in Group DEX-A ($p < 0.001$).

Serial tracking of postoperative pain via VAS scores at rest and during movement revealed comparable pain control during the initial 6 hours post-surgery, with both adjuvants providing excellent analgesia (VAS < 3). However, at 12 hours and 18 hours postoperatively, patients in Group DEX-M exhibited significantly lower mean VAS scores both at rest (2.4 ± 0.8 vs. 3.6 ± 1.0 at 12 hours, $p < 0.001$) and during movement (3.2 ± 0.9 vs. 4.4 ± 1.1 at 12 hours, $p < 0.001$), reflecting the superior analgesic longevity of perineural dexmedetomidine.

Table 2 : Comparison of Postoperative Analgesic Efficacy and Visual Analog Scale Pain Scores between Dexmedetomidine (DEX-M) and Dexamethasone (DEX-A) Adjuvant Groups

Analgesic Outcome / VAS Timepoint	Group DEX-M (n = 45)	Group DEX-A (n = 45)	Difference (95% CI)	p-value
Duration of Analgesia (hours), Mean ± SD	14.8 ± 2.6	11.4 ± 2.2	3.4 (2.4 to 4.4)	< 0.001
Total 24h Tramadol Consumption (mg)	68.4 ± 18.5	92.6 ± 24.2	-24.2 (-33.2 to -15.2)	< 0.001
Patients Requiring Rescue Analgesia, n (%)	32 (71.1%)	41 (91.1%)	OR = 0.24 (0.07 to 0.83)	0.02
VAS Score at Rest (0–10 Scale)				
2 Hours Post-op	1.6 ± 0.6	1.8 ± 0.7	-0.2 (-0.5 to 0.1)	0.15
6 Hours Post-op	2.1 ± 0.7	2.3 ± 0.8	-0.2 (-0.5 to 0.1)	0.21
12 Hours Post-op	2.4 ± 0.8	3.6 ± 1.0	-1.2 (-1.6 to -0.8)	**< 0.001**
18 Hours Post-op	2.8 ± 0.9	3.4 ± 0.9	-0.6 (-1.0 to -0.2)	0.002
24 Hours Post-op	2.5 ± 0.7	2.7 ± 0.8	-0.2 (-0.5 to 0.1)	0.21
VAS Score on Movement (0–10 Scale)				
12 Hours Post-op	3.2 ± 0.9	4.4 ± 1.1	-1.2 (-1.6 to -0.8)	**< 0.001**
18 Hours Post-op	3.6 ± 1.0	4.2 ± 1.0	-0.6 (-1.0 to -0.2)	0.005

Analysis of postoperative side effects revealed distinct clinical profiles associated with each adjuvant (Table 3). Patients receiving perineural dexamethasone (Group DEX-A) experienced a significantly lower incidence of postoperative nausea and vomiting (PONV) compared to those receiving dexmedetomidine (8.9% vs. 24.4%, $p = 0.04$), demonstrating the robust systemic antiemetic absorption of dexamethasone from the fascial plane.

Conversely, patients in Group DEX-M exhibited a higher incidence of early postoperative sedation (Ramsay Sedation Scale ≥ 3 during the first 4 hours) compared to Group DEX-A (15.6% vs. 2.2%, $p = 0.03$). This sedation was mild, arousable, and transient, resolving spontaneously without any instances of respiratory depression ($SpO_2 < 92\%$ or respiratory rate < 10 bpm). Mild bradycardia (HR 45–50 bpm) was observed in 3 patients (6.7%) in Group DEX-M vs. 0 patients in Group DEX-A ($p = 0.24$), none requiring atropine intervention.

Table 3: Incidence of Postoperative Adverse Effects and Sedation in Patients Receiving Perineural Dexmedetomidine (DEX-M) versus Dexamethasone (DEX-A) during Laparoscopic Hysterectomy with Transversus Abdominis Plane Block

Postoperative Adverse Event	Group DEX-M (n = 45)	Group DEX-A (n = 45)	Relative Risk / OR	p-value
Postoperative Nausea & Vomiting (PONV), n (%)	11 (24.4%)	4 (8.9%)	RR = 2.75 (0.95 to 7.96)	**0.04**
Early Sedation (RSS ≥ 3 at 2–4 hours), n (%)	7 (15.6%)	1 (2.2%)	RR = 7.00 (0.89 to 54.8)	**0.03**
Bradycardia (Heart Rate < 50 bpm), n (%)	3 (6.7%)	0 (0.0%)	OR = 7.42 (0.37 to 148.6)	0.24
Hypotension (MAP < 65 mmHg), n (%)	2 (4.4%)	1 (2.2%)	RR = 2.00 (0.19 to 21.2)	1.00
Pruritus / Dizziness, n (%)	2 (4.4%)	3 (6.7%)	RR = 0.67 (0.12 to 3.80)	0.64
Local Abdominal Wall Hematoma / Infection	0 (0.0%)	0 (0.0%)	N/A	1.00

DISCUSSION

A recent study conducted at a Bengaluru tertiary care hospital indicated that both dexmedetomidine and dexamethasone are highly effective perineural adjuvants to bupivacaine in ultrasound guided transversus abdominis plane block for total laparoscopic hysterectomy [1, 3]. Our major results show that dexmedetomidine produces significantly prolonged analgesia when compared with dexamethasone (14.8 ± 2.6 hours vs. 11.4 ± 2.2 hours, $p < 0.001$). It reduced the cumulative 24-hour tramadol consumption by 26% (68.4 mg vs. 92.6 mg) and resulted in superior VAS pain control at 12 and 18 hours postoperatively [6, 7]. Dexamethasone does offer a specific clinical advantage with respect to postoperative nausea and vomiting (8.9% vs. 24.4%, p=0.04); the incidence of early sedation is lower [5, 8].

Our empirical purport literature on modern regional anesthesia and provide important clinical synthesis. We support the systematic findings reported by Alreefi et al. [3] and Wang et al. [6] that perineural alpha-2 agonist is significantly superior to corticosteroids in terms of prolonging the period of sensory blockade Following abdominal wall fascial plane blocks. In the Indian context of health care, our results are in accordance with the recent prospective observations of Sharma et al. [7] and Karthik et al. [8]. The former assessed regional adjuvants in a South Indian cohort of gynaecological oncology patients, and the latter in surgical oncology patients. All three studies report that dexmedetomidine provides better opioid-sparing analgesia while dexamethasone provides superior recovery comfort as an antiemetic which also has substantial synergistic benefits on the overall analgesic effect.

The differences in the painkilling effect and the side effects can be explained by their neurobiological mechanism of action. The prolonged analgesic effect of dexmedetomidine occurs when the drug acts locally by causing hyperpolarization of the cation-activated (Ih) currents in unmyelinated C-fibers and myelinated A-delta fibers. Dexmedetomidine also causes local perineural vasoconstriction through its alpha-2 effects, limiting the systemic absorption of bupivacaine[6, 7]. The study details the 3.4-hour block duration extension seen in Group DEX-M [6, 7]. Nonetheless, the modest systemic absorption dexmedetomidine, according to our study, was also responsible for the transient early sedation (15.6%) and mild bradycardia [3, 7]. In comparison, dexamethasone prolongs the effects of local anesthetic blockade through nociceptive C-fiber electrical transcription downregulation, ectopic neural discharge suppression, and local inflammatory mediator synthesis inhibition [5, 8].

While perineural dexmedetomidine has a somewhat shorter analgesic extension than that of dexmedetomidine, the systemic absorption of perineural dexamethasone from the vascular TAP plane block central chemoreceptor trigger zones and prostaglandin synthesis; thus explaining the very significant (3-fold) reduction in PONV in Group DEX-A [5, 8]. The ERAS protocols of TLH stresses the early oral intake and ambulation. An optimal personalized approach is selecting the chosen adjuvant based on certain risk factors. Dexamethasone can be prioritized in patients at high risk of PONV [4;8] and dexmedetomidine in an opioid intolerant patient with extreme pain sensitivity.

It is important to highlight certain limitations of the data obtained from this study. Single-center study with a cohort size of N = 90 patients; while statistically powered to detect significant differences in block duration and opioid consumption, it may not be adequately powered to detect rare regional complications. Larger multicenter studies are required to evaluate these regional complications [3, 8]. In addition, as an observational comparative study and without a placebo control group (bupivacaine alone), our study evaluated relative superiority rather than absolute adjuvant prolongation over unassisted bupivacaine, although historical controls confirm unassisted TAP blocks last only 6 to 8 hours [5, 6]. In conclusion, the analgesia provided by TAP blocks is chiefly for somatic abdominal wall pain. Even though our multimodal regimen was effective for visceral pain, the addition of TAP blocks in future comparative adjuvant trials with visceral plane blocks (quadratus lumborum block) will aid in the optimisation of TLH analgesia [2, 7].

CONCLUSION

The use of dexmedetomidine and dexamethasone is safe and effective as perineural adjuvants to bupivacaine. Dexmedetomidine ensures a better quality of postoperative analgesia for longer times with less 24 hr consumption of opioids. On the other hand, dexamethasone has as clinical advantage of reducing postoperative nausea and vomiting with minimal early sedation. Anesthesiologists in the enhanced recovery gynecological protocols should choose the adjuvant according to specific risk profiles.

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